

A Q U A P H Y T E



CENTER FOR AQUATIC PLANTS

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University of Florida

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U.S. TEAM SURVEYS COLOMBIA

In the U.S., aquatic weeds can be managed using combinations of many plant management tools: herbicides, insects, fish, machines...

But consider the dilemma in Colombia, South America: their aquatic weed problems are causing increasing economic and environmental damage, but their only legal management tools are mechanical controls. Aquatic herbicides are not registered for use there and the importation of host specific biocontrol agents are not currently approved in Colombia.

In Laguna de Tota, approximately one sixth of the 15,000 acre lake is infested with the submersed plant, *Egeria densa*, which interferes with fisheries, recreational boating, and potable and industrial water supplies. In Laguna de la Playa, the entire lake is covered with floating water hyacinths (*Eichhornia crassipes*) which interfere with irrigation and with cooling water needs of the coal fired electric generating plant. The floating plants also cause flooding problems and threaten the integrity of an earthen dam and spillway. In Laguna de Fuquene, emergent grasses cover more than 2,500 acres and floating plants, mostly *Eichhornia crassipes*, cover 500 acres, interfering with flood control, irrigation, and navigation.

To address these problems and to learn of other ways to manage aquatic plants, Colombia held its first international aquatic plant management meeting. Approximately 100 managers, engineers and scientists from several South American countries and the U.S. attended the *Seminario Internacional Sobre Plantas Acuaticas* in Bogota in April 1989. The seminar was sponsored by the Corporacion Autonoma Regional (CAR) and the Organization of American States (OAS).

At the same time, Drs. Joseph Joyce (University of Florida Center for Aquatic Plants), Randall Stocker (Imperial Irrigation District, California), Gary Buckingham (U.S. Department of Agriculture, Gainesville, Florida) and Mr. John Gallagher (Retired, Union Carbide), were invited to visit Colombia to assess the aquatic weed problems in the CAR area of responsibility. The team's specific mission was to identify and view various aquatic weed problems, and to provide recommendations for practical solutions to the management of nuisance aquatic weeds in the CAR region and other waters of interest.

[See COLOMBIA on page 6]

BRAZILIAN WATER HYACINTH INFESTATION

by Gilberto Pedralli, MSc., SNE/CETEC, Caixa Postal 2306, CEP 31.170, Belo Horizonte, MG, BRASIL.

The Volta Grande reservoir, with a flooded area of 205 square kilometers is located between parallels 48 25' and 47 35 WGr., and 19 57'52" and 20 10'00". It comprises part of the municipal districts of Conceicao das Alagoas, Aqua Comprida and Uberaba in Minas Gerais State, and Miquelopolis, Aramina and Igarapava in Sao Paulo State, Brazil.

[See BRAZIL on page 7]



Mechanical harvesting represents the only currently approved method of managing aquatic vegetation in Colombia. Draglines are used extensively to remove emergent and floating aquatic vegetation from irrigation and flood control canals and from water supply reservoirs.

INFORMATION OFFICE

APIRS UPDATE

Much has transpired at APIRS lately. Read on for important news for APIRS users.

WE HAVE MOVED! APIRS is now housed at the Center for Aquatic Plants, 7922 N.W. 71 Street, Gainesville, Florida 32606. The telephone number remains the same: (904) 392-1799.

The APIRS database has been taken off the university mainframe and is currently housed in the APIRS office. The database is now on an IBM/PC-AT with a 230 megabyte Priam hard-disk. Using the Xenix Operating System and the BRS Search software, our 26,000 citation database is now quickly and easily accessible for on-screen searching and viewing. We are not yet interactive for remote users and we do not produce bibliographies on floppy disks. We will keep you posted on new developments.

APIRS no longer produces automatic updates to users' bibliographies. Those of you who wish to update your bibliographies now need to request this service.



Video team members Vic Ramey, Phil Chiochio and Karen Brown on Lake Istokpoga with Wayne Jipsen (USACOE).

Photo courtesy of Terry Sullivan, Fla. DNR.

THIS MAY BE YOUR LAST ISSUE OF AQUAPHYTE! "Florida Statute 283.28 requires biennial verification of all mailing lists maintained by state agencies for the purpose of distributing free publications to the public."

In simpler terms, if you wish to continue receiving **AQUAPHYTE**, **YOU MUST COMPLETE AND RETURN THE FORM** located on page 15. Please cut out the form as your mailing label is on the reverse side and we need both.

VIDEO NEWS

The latest addition to the Center's information office is a video production unit, which was funded by a grant from the Florida Department of Natural Resources, Bureau of Aquatic Plant Management. The unit produces educational videotape programs for the general public and aquatic plant management personnel.

Two programs have been completed and are available for distribution:

CALIBRATION: A FIELD APPROACH was produced for the benefit of aquatic herbicide applicators, both as a learning tool for new applicators and a refresher for those with experience. This is the first of a series on equipment calibration and herbicide application. The program features Dr. William Haller and is 35 minutes long.

ISTOKPOGA - LAKE OF LEGENDS was produced to tell the story of one of Florida's largest lakes, which recently underwent the largest herbicide treatment against hydrilla in Florida history. It recounts the citizen activism and agency cooperation which resulted in this large application of fluridone. The program is 39 minutes long.

Additional programs are in production, including an overview of aquatic plant management and an overview of freshwater systems in Florida, both for the general public.

The videotapes are in the VHS format and are available free of charge to in-state agencies and public groups. For information, contact the APIRS office.

HELP WANTED

The video production team travels throughout Florida to collect video footage for the programs. Any tips on upcoming events in the aquatic plant world are appreciated.

Contact the APIRS office with any information on new or unusual research experiments, biocontrol releases, aquatic plant infestations, restoration projects, etc.

A T T H E C E N T E R

Allelopathy Studies

Work continues on the evaluation of the allelopathic potential of native aquatic plants and their interaction with hydrilla.

In one of his recent studies, Dr. David Sutton (of the IFAS Research Center in Ft. Lauderdale) examined whether the submersed arrowhead (*Sagittaria subulata*) was capable of resisting colonization by hydrilla (*Hydrilla verticillata*). In this experiment, Sutton found the number of tubers was 59% lower for hydrilla planted in established stands of arrowhead plants as compared to hydrilla cultured alone.

In another experiment, four allelochemicals were examined for their effects on the growth of duckweed (*Lemna paucicostata*). Sutton found that aqueous extracts from shoots of dried spikerushes, *Eleocharis interstincta* and *Eleocharis cellulosa*, exhibited growth retarding effects on the number of duckweed plants.

Fluridone Degradation

Dr. Donn Shilling and Dr. William Haller are evaluating the role of light (photolysis) and microorganisms on the degradation of the herbicide fluridone. In other work, they hope to develop a quick, reliable method for determining fluridone concentrations in treated water. One procedure they use has a detection limit of 50 to 100 parts per trillion.

Flood Control Benefits

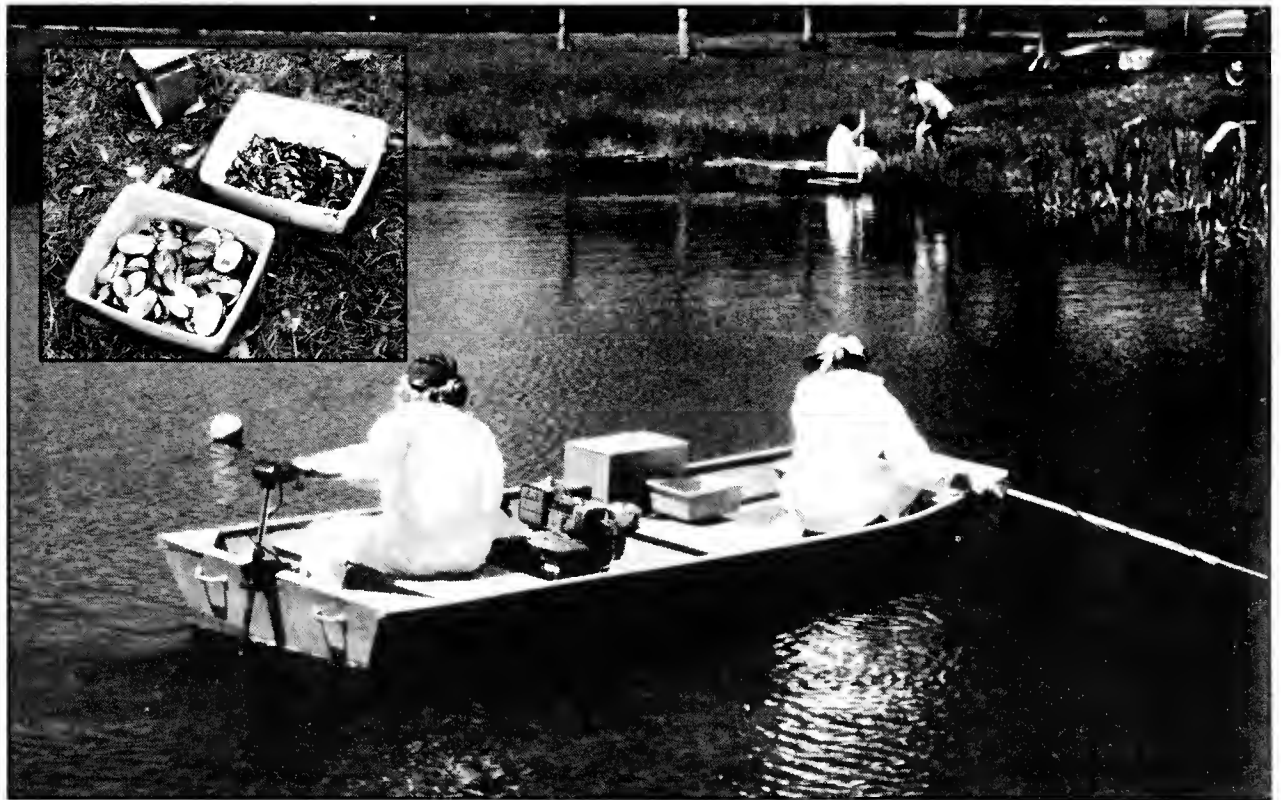
A study to determine a technique to estimate the benefits of aquatic plant control in water control canals in South Florida is being conducted by E.M. Thunberg, J.W. Milon and N. Pearson of the IFAS Department of Food and Resource Economics. With the technique, cost-benefit ratios can be calculated to determine optimum levels of plant control to be maintained in 298 district canals.

Biocontrol of Algae - Viruses

In his continuing research, Dr. Edward Philips of the IFAS Department of Fisheries and Aquaculture has identified viruses (cyanophages) which attack several species of nuisance blue-green algae, including *Lyngbya birgei*, *Microcystis aeruginosa*, *Anabaena flos-aquae* and *A. circinalis*. Detailed experiments are underway to help determine the best timing for phage inoculation in algal mat development.

Biocontrol of Algae - Fishes

The reduction of large algal populations using fish is the subject of a study being conducted by Dr. Jerome Shireman, Dr. Daniel Canfield and Dr. Karel Opuszynski (IFAS Department of Fisheries and Aquaculture). In six ponds adjacent to Lake Apopka, bighead carp (*Aristichthys nobilis*) will be used to control large algae, and grass carp (*Ctenopharyngodon idella*) will be used to control macrophytes. The study is being funded by the St. Johns Water Management District with SWIM funds.



Evaluation of Bensulfuron

Under an experimental use permit (EUP), the Center's Dr. Ken Langeland and Mr. Francois Laroche are conducting several studies to evaluate the herbicide bensulfuron for possible use in Florida aquatic plant management. To be marketed as MARINER, bensulfuron is manufactured by E.I. Du Pont de Nemours & Co.

Pictured above, studies on the environmental fate of bensulfuron include determining residues and accumulation in fish, clams, crawfish, sediments and water. The closed system studies took place in the research ponds at Welaka, Florida.

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INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES
UNIVERSITY OF FLORIDA
7922 N.W. 71ST STREET
GAINESVILLE, FLORIDA 32606
(904) 392-9613

Dr. Joseph Joyce, Director

WATER HYACINTH

BANGLADESH'S BEAUTIFUL BLUE BURDEN

by M.F. Rodman, Northwest Hydraulic Consultants Ltd., 444
Brooksbank Avenue, North Vancouver, B.C., CANADA V7J 2C2

The writer recently spent a total of ten years in Bangladesh working on flood control and irrigation projects sponsored by the World Bank and the Canadian International Development Agency. These projects were some of the many in that country aimed at increasing agricultural production by preventing flooding of agricultural land. Thus, the growing season was extended so that in some locations at least one crop could be harvested and in other locations an additional second or a third crop could be produced. In most of the projects irrigation water was supplied to augment the rainfall in the monsoon season for one or two crops. In many areas water was supplied in the dry season to permit a second or even a third crop.

Each year the annual floods, during their advent and recession, cause damages to infrastructure and crops. However, these floods also provide water for the soil and facilitate the movement of boats to transport personnel and to carry produce to and from market. Sixty percent of all transport in Bangladesh is by boat over the flooded fields and along the myriads of interconnected water courses called *khals*.

In the course of the work on these projects the writer had occasion to visit most of the regions in the country. It was observed that water hyacinth was a scourge causing uncounted economic losses and that it was significantly on the increase. Accordingly, a limited survey was carried out privately which tended to confirm the foregoing observations.

Bangladesh provides a warm habitat in which water hyacinth can thrive in its many nutrient laden water bodies. Damage, for

the most part, results from floods which spread it from its place of growth into the farmers fields and channels where it damages crops and impedes agriculture and navigation. Eighty five percent of Bangladesh's population reside in rural areas and live by agricultural pursuits.

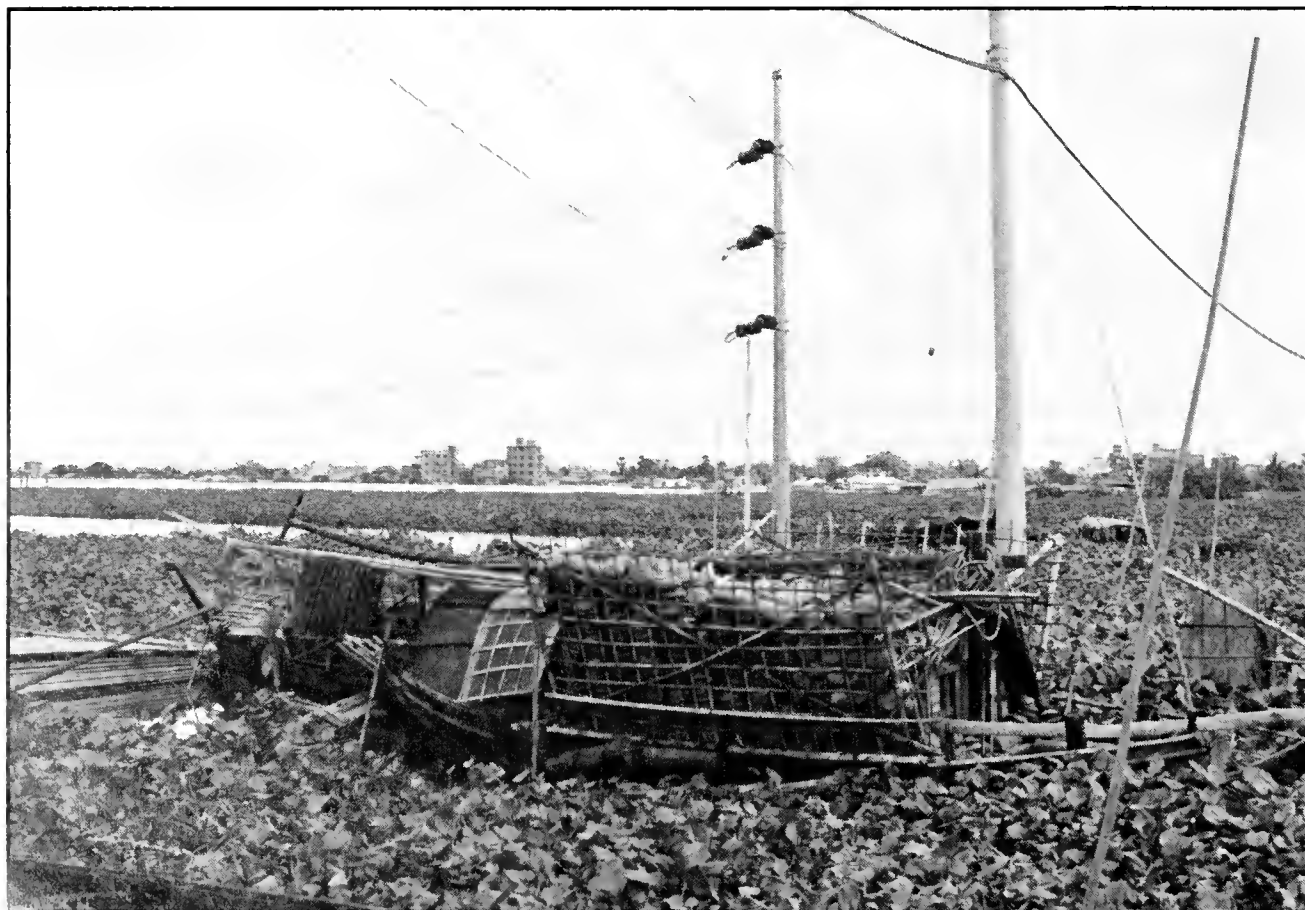
In view of the foregoing it is believed that this country has one of the most serious infestations in the world and an even greater relative amount of economic damage than most countries. No significant attempts have been made to date to control this weed.

This paper, after commenting on the status of water hyacinth in the world in general, describes the status of it in Bangladesh, the nature of the damages caused and additionally an approach to its control.

WATER HYACINTH WORLD WIDE

Water hyacinth is an emergent and free floating macrophyte which originated in South America and was noted first in Brazil early in the 19th century. Towards the end of that century it had spread to several tropical and sub-tropical countries in Asia, Africa and North America. Its spread has largely been attributed to the beautiful blue flower; when seen at horticultural exhibitions, it was taken home by overseas visitors to their botanic gardens, from where it spread to the waterways. It continued to spread during the 20th century and is now infesting many countries in South and Central America, the United States, 15 countries of Africa, 10 countries of South and East Asia, 7 countries of the Pacific Ocean, Australia, New Zealand and Portugal.

The economic and environmental problems caused by water hyacinth in several countries are matters of great concern and have been the subject of a great deal of study. In most countries it is pestilent and in many it is seriously damaging to the environment. The proliferation of the weed has been accompanied by a corresponding productivity of some 2000 research scientists throughout the world and some in Bangladesh. These scientists have published over 60,000



**Cargo boats
trapped in
water hyacinth
during flood
season.
Dhaka suburbs.**

pages in some 600 scientific research reports, magazines, periodicals and conference proceedings. Over a period of five years in the 1980s the quantity of literature doubled and much research and many reviews of the literature continue to be published and conferences and seminars to be held. This research and study has resulted in much available technical information on its control but to date, with several notable exceptions, has had a disproportionately small amount of cost-effective control being organized to utilize it.

Large scale eradication of water hyacinth has been attempted in some countries. Permanent eradication has not proved feasible in most cases due to its ability to proliferate rapidly from a small infestation. It has been eradicated from relatively isolated bodies of water or water-sheds where reinfestation could be prevented. In many cases on-going eradication programs have changed to control programs. Control requires a major initial effort to reduce the infestation to a level at which it is no longer seriously damaging and at which level its control is possible and affordable. Control measures include mechanical removal, herbicides and biological enemies. The stocking into its habitat of biological enemies such as certain insects, pathogens and fungi holds promise of efficient long term control of this weed.

WATER HYACINTH IN BANGLADESH

The topography and climate of Bangladesh provide an ideal environment for proliferation of aquatic weeds, especially water hyacinth. Almost the whole of the country consists of a flat low-lying delta laced with tranquil watercourses and 'beels' (water-filled depressions). Two of the world's major rivers and many small rivers flow into Bangladesh from India. The northeast section of the country is drained by the mighty Meghna which with its tributaries spreads out over the land forming a vast lake over much of the districts of Syhlet and Mymensingh. Their waters plus local precipitation ultimately debouch into the Bay of Bengal through several main channels. Each monsoon season the water floods out of other rivers as well and thus up to two-thirds of the country is covered depending on the intensity of each year's floods. These waters lift the water hyacinth from its place of growth and transport some of it out to sea but large quantities spread out into the rivers, irrigation and drainage channels, reservoirs, *beels* and over the land. In that manner the weed spreads to, and proliferates in, these new locations.

Water hyacinth has the ability to grow in deep tranquil water, in shallow water or in areas which remain saturated during the dry season. It grows from germination of seeds but in most circumstances by the horizontal spreading of its stolons floating on the water and is able to thrive in a variety of habitats. Such habitats abound in Bangladesh.

During the last three decades, many low lying areas between the water courses have been empoldered with embankments. In a number of polders, watercourses have been cut off and used as reservoirs, or as canals to distribute irrigation water, or for drainage. These relatively tranquil water surfaces have added to the already numerous habitats for water hyacinth and partly account for the recent increase in its growth. It is also likely that an increase in fertilizer use in the last three decades, together with an increase of animal and human wastes, related to population growth, have exacerbated the water hyacinth problem.

From reported observations made during field trips and observation flights by personnel working on the various water resources projects throughout the country it is evident that the water hyacinth is widespread and notably increasing. To date no significant control measures have been taken in Bangladesh. This lack of action is no doubt attributable to lack of awareness by authorities regarding the economic damage occurring, preoccupation with more visibly urgent development problems, and unfamiliarity with workable control measures and finally insufficient funds to implement these measures.

NATURE OF DAMAGES

CROPS

When flood waters aided by wind, force a mass of water hyacinth against a standing crop, the crop is sheared off. Subsequently, as the water level falls the mass crushes down on the crop and destroys it. Rice and jute are especially vulnerable to such damage. When the flood waters have receded it is necessary for the farmer to remove the stranded water hyacinth, whether it has landed on top of a crop which it has damaged or simply on the bare land which he intends to cultivate. The Bangladesh Water Development Board (BWDB) receives many requests for aid from farmers, to pay for the removal of this weed, or to build barriers against water hyacinth invasions.

FISHERIES

Research has shown that the growth of most species of fish is seriously inhibited by dense masses of water hyacinth, due in part, to depletion of oxygen and nutrients. One exception to this appears to be the Chinese grass carp which feeds on aquatic weeds but this fish does not occur nor will it regenerate itself if stocked in Bangladesh. Water hyacinth may be a significant contributing factor to the reported decrease in the annual yield of freshwater fish. The weed also impedes fish harvesting by fouling nets and impeding access to the fishing grounds.

RIVER TRANSPORT

The rivers, *khals* and *beels* are used for the water transport of over sixty percent of Bangladesh goods and passengers. This transport is frequently impeded by masses of the weed in the open waters, channels, and harbours.

WATER LOSS

Research has shown that evapotranspiration from a dense mat of water hyacinth is from two to six times greater than from a free water surface. The water loss varies with the wind, temperature, air humidity, and density of the plant, and is a matter of great significance in many reservoirs. Bangladesh has serious problems in storing the water it requires for the dry season and can ill afford such large losses from storage.

FLOW RESTRICTION

Water hyacinth restricts flow by reducing the cross-section and increasing the hydraulic friction factor of any channel it infests as determined by studies in Egypt and elsewhere.

[See **BANGLADESH** on page 6]

[BANGLADESH from page 5]

Thus, either the channel size must be increased or the water hyacinth must be removed to maintain a given hydraulic capacity. If there is a silt load in the channel, sedimentation in the zones occupied by water hyacinth further restricts flow.

DISEASE

Masses of the weed provide a habitat for disease-carrying mosquitoes and other obnoxious insects and snakes. The City of Dhaka carries out an aerial and ground spraying program against mosquitoes which is costly but only partly effective.

BENEFITS

In spite of all its detriments, water hyacinth currently does provide some benefits. Many cattle feed on it, getting about fifteen percent of their nourishment from its stem. It is said that they will consume it only reluctantly in the absence of other feed.

Water hyacinth is used to some extent for green manure, mulch on the land, and as a curing blanket for newly placed concrete. In certain places pods of the weed are anchored in the water. The fish will concentrate in the shade near the outer edges of a pod, facilitating harvesting operations but this does not help the growth of more fish.

At the present time it appears that the foregoing or other benefits are minimal compared with the losses previously described above.

AN APPROACH TO CONTROL

In recent years research has indicated that the weed may be utilized for various purposes. However, utilization programs may distract from, postpone, or even cause abandonment of vital control strategies. Conflict of interests may be avoided by developing a control program that simultaneously allows both small and large scale utilization. Control of the growth of the weed is already available. Failures in control have often resulted when only one method has been utilized. It is therefore apparent that in many circumstances, control should involve an integration of mechanical, chemical and biological means. The development of utilization methods should be pursued and included within the control program provided they hold promise of being economically viable in their own right.

In Bangladesh there are many flood protected areas (polders) and river basins which, once cleared, would not be reinfested. However, all have small water control sluices for flushing irrigation water into the polders in the dry season. Such structures would have to be provided with screens to prevent the plant from entering the polder or basin. In this circumstance it should be possible to implement an eradication program which would integrate mechanical, chemical and biological control methods. In most of Bangladesh, however, the movement of the flood waters carrying water hyacinth would quickly reinfest any area from which the weed had been eradicated. Therefore, an integrated program directed at control, rather than eradication, would have to be followed. It would appear that ultimately, and in the long run, biological control once developed would be the principal tool with which to deal with this weed. Since there are identifiable migration routes on the flood waters, it is very conceivable that large

areas could be controlled by planting the biological agents in certain points from where they could redistribute themselves over large areas.

Bangladesh has experienced disastrous tidal waves in 1970 and 1985 which killed up to 300,000 people and otherwise caused great damage. A major flood occurred in 1987 and the country had just begun to repair the damages from it when the worst flood in history struck the country again in 1988. The latter caused from 10 to 20 million people to abandon their homes and cling to tree tops, high buildings and railway or other embankments without protection from the rains, drinking water, food or medical aid. The author witnessed all of these events and marvelled at the stoicism and resilience with which the people reacted and recovered.

Water hyacinth cannot strike so suddenly nor horrendously as a tidal wave or flood can do. Fortunately it is within the power of man to control it and to minimize the damages which would otherwise occur.

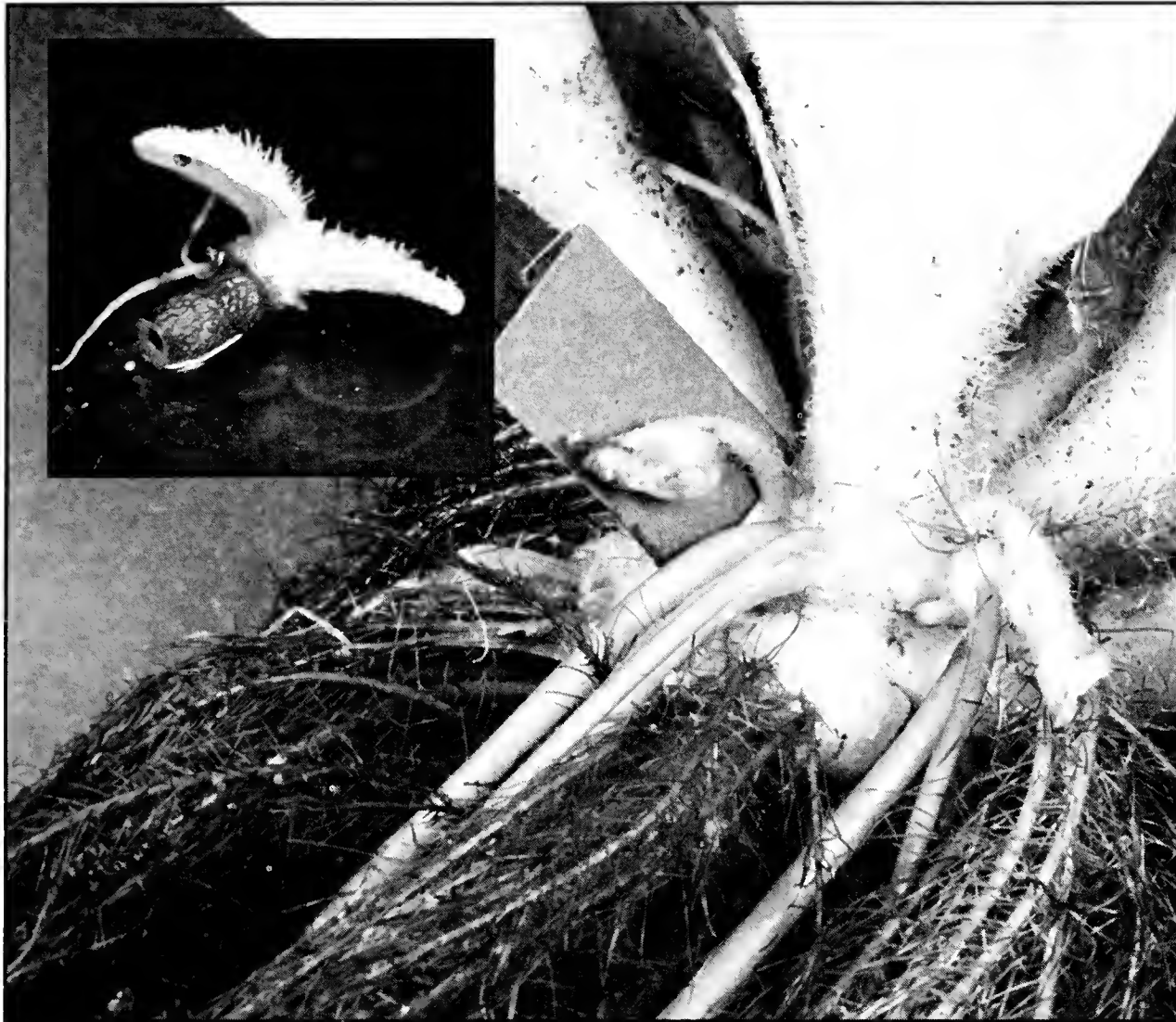


[COLOMBIA from page 1]

Most of the team's recommendations suggested a combination of herbicidal, biological and mechanical methods for aquatic plant management in Colombia.

For biological control options, the team recommended that a Colombian biologist study the possibilities of introducing herbivorous insects to control *Eichhornia crassipes* and *Egeria densa*. Triploid grass carp were recommended for introduction into waters where total submersed weed control is desired.

For herbicidal control options, the team recommended that steps be taken to register certain aquatic herbicides for use in Colombia, and that a research facility capable of conducting both basic and applied research be established. It was recommended that ongoing applicator training programs be developed, and that detailed records be kept to monitor herbicide use. The team also recommended that an extensive education program be conducted for the general public and non-weed scientists.



Above: Water lettuce (*Pistia stratiotes*) reportedly does not produce fruits and seeds in the United States. However, F. Allen Dray, Jr. and Ted D. Center have reported in *AQUATIC BOTANY* (v. 33:155-160, 1989) that water lettuce fruits and seedlings do occur in many locations in Florida. In one mat, seeds averaged 726 seeds per square meter and sediments held 4196 seeds per square meter. Germination experiments showed that more than 80% of the seeds were viable.

[BRAZIL from page 1]

The exotic species *Eichhornia crassipes* and *E. azurea* was introduced in the Rio Grande's basin in March 1987, into effluent treatment ponds of alcohol distilleries and phosphate production plants.

These ponds, with an approximate area of 30 ha, were occupied by the water hyacinth in less than 6 months. During the rainy season (November 1987 to March 1988), there was an increase in both pond and reservoir levels, and a communication between the water masses allowed the seeds and vegetative parts of the mentioned species to pass into the reservoir.

It is possible to observe that the edges of the reservoir and islands are quickly being taken up by individuals of the two species, even in areas located as far as 30 Km downstream of the ponds. This became even more worrisome when those individuals were found close to the dam.

These facts were reported to Companhia Energetica de Minas Gerais (CEMIG), which is the concessionary of

the hydroelectric power station. Therefore we were asked to prepare and to carry out a program for monitoring, zonation and controlling both species. We are carrying out this program together with technicians of the Volta Grande Fish-Breeding Station, in order to reduce to as little as possible the negative impact they could cause to the hydroelectric power station.

The multiple-use purpose of the reservoir water means that the only alternative for control is mechanical. Therefore, it was recommended that the perimeter size of the ponds be reduced through earthworks, in order to make it possible to control the biomass by removing it with specially adapted machines.

Retention systems for the water hyacinths are being introduced according to our suggestion. These consist of barriers of different meshes placed in the channels which link the ponds and the reservoir. These barriers will be cleaned periodically.

Many reports have been made about the introduction of aquatic macrophytes with high capacity to occupy lentic environments with their high growth rates, and the negative impacts they may cause.

The costs of controlling these plants and reducing their negative impacts is too high. Therefore, those costs should be charged to those who introduced the species in environments where they used to not be found.



Water hyacinth infestation in the Rio Grande basin.

FROM THE DATABASE

Here is a sampling of recent research articles, books and reports which have been entered into the aquatic plant database since January, 1989.

To receive free bibliographies on specific plants and/or subjects, contact APIRS at the address shown on the mail label on page 16.

To obtain articles, contact your nearest state or university library.

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BOOKS/REPORTS

AQUATIC PLANT IDENTIFICATION AND HERBICIDE USE GUIDE.

Volume I: Aquatic Herbicides and Application Equipment, 222 pages; Volume II: Aquatic Plants and Susceptibility to Herbicides, 104 pages; both edited by H.E. Westerdahl and K.D. Getsinger. 1988. Technical Report A-88-9. U.S. Army Corps of Engineers.

(Order from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.)

Volume I provides information on the use and fate of 10 registered herbicides for managing nuisance aquatic vegetation. Site factors affecting herbicide selection, including water body uses, water quality and hydrology are discussed. The selection and calibration of herbicide application equipment, for use with liquid and granular formulations, is examined.

Volume II includes color photographs, drawings and descriptions of more than 50 aquatic plant species, and includes a guide for herbicide susceptibility and selection for each specie.

WETLAND PLANTS AND PLANT COMMUNITIES OF MINNESOTA AND WISCONSIN

by S.D. Eggers and D.M. Reed. 1987. 201 pp. U.S. Army Corps of Engineers, St. Paul District.

(Order from Department of the Army, St. Paul District, Corps of Engineers, ATTN: CENCS-LM/SALES AGENT, 1421 U.S. Post Office and Customs House, St. Paul, Minnesota 55101-1479. \$6.50)

The wetlands of these two states are categorized into 15 plant communities. Plant communities and 115 plant species are described and illustrated by color photographs.

BIOLOGY AND CONTROL OF WATER MILFOIL:

1)An Annotated Bibliography; 2)Supplementary Bibliography, compiled and edited by D. Hesel and A.L. Baker. 1989.

(Order from Water Milfoil Project, University of New Hampshire, Nesmith Hall, Durham, New Hampshire 03824-3597. (603) 862-3845. Annotated Bibliography is \$5; Supplementary is \$20).

These two bibliographies include 528 citations and abstracts. They are organized into several sections: biology,

general control, biological control, chemical control, mechanical control, environmental control, and impact of control measures on lakewater quality.

NORTHERN PRAIRIE WETLANDS,

edited by A. van der Valk. 1989. 400 pp. (Order from Iowa State University Press, 2121 South State Avenue, Ames, Iowa 50010. This is publication number 44 of the Marsh Ecology Research Program, a joint project of the Delta Waterfowl and Wetlands Research Station and Ducks Unlimited Canada.)

It is estimated that 50-75% of North America's ducks breed in the wetlands of the prairie pothole region which extends from Iowa, USA to Alberta, Canada. This hardbound book includes 12 chapters which review the ecology of these palustrine and lacustrine wetlands.

Chapters deal with waterfowl, agricultural impacts, wet-dry cycles and water chemistry. Other chapters deal with the composition, classification and dynamics of vegetation of these wetlands and the food chains that they support.

RESTORATION, CREATION, AND MANAGEMENT OF WETLAND AND RIPARIAN ECOSYSTEMS IN THE AMERICAN WEST.

A Symposium of the Rocky Mountain Chapter of the Society of Wetland Scientists. November 14-16, 1988, Denver, Colorado. 1989. 239 pp.

(Order from Kathryn Mutz, Planning Information Corporation, 1801 Broadway, Suite 920, Denver, Colorado 80202. (303) 298-0919.)

This is a collection of 43 papers on wetland policy, creation, restoration, management and utilization.

WETLAND AND RIPARIAN ECOSYSTEMS OF THE AMERICAN WEST - PROCEEDINGS OF THE SOCIETY OF WETLAND SCIENTISTS'

EIGHTH ANNUAL MEETING. May 26-29, 1987, Seattle, Washington. 1988. 349 pp.

(Order from Kathryn Mutz, Planning Information Corporation, 1801 Broadway, Suite 920, Denver, Colorado 80202. (303) 298-0919.)

This is a collection of 69 papers on wetland description and delineation, policy and regulation, nutrient and organic matter dynamics, hydrology, community ecology, creation and restoration, remote sensing, landscape ap-

proaches, ecophysiology and herbivory, assessment and management, population ecology, fish and wildlife interactions.

THE EFFECT OF GRASS CARP INTRODUCTION ON AQUATIC VEGETATION AND EXISTING FISH POPULATIONS IN TWO SMALL PRAIRIE LAKES,

by D.L. Bauer, MS Thesis, South Dakota State University. 1988. 85 pp.

The author reports findings from two South Dakota lakes. The lakes were stocked with triploid grass carp at 49 and 61 fish per hectare. During a two year period, grass carp significantly reduced vegetation coverage and height in the lake with the lower stocking density, but did not significantly reduce vegetation coverage or height in the lake with the higher stocking density. No conclusions were drawn about the effect of grass carp introduction on the existing fish populations in the two lakes.

ENVIRONMENTAL ASSESSMENT. AQUATIC PLANT MANAGEMENT (NR 107) PROGRAM.

Wisconsin Department of Natural Resources, 1989. 212 pages.

(For information contact Ed Jepsen, Environmental Analysis and Review, Wisconsin Department of Natural Resources, Box 7921, Madison, Wisconsin 53707.)

This assessment includes everything you wanted to know about aquatic plant management activities in Wisconsin. The assessment was undertaken "to respond to the continuing controversy over the aquatic nuisance control program" in that state. Its primary goal is to "integrate and coordinate aquatic plant control activities with related Department programs."

The assessment details the department's aquatic plant management philosophy, policies, history, permitting procedures and legal authority. It reveals survey results about lake uses and users, and economic effects of aquatic plant control on property values, tourism and commercial sales. It discusses physical controls (17 methods!), biological controls, and herbicides. It includes 12 appendices on subjects such as the pesticide registration process, endangered species and FIFRA and toxicity and includes lists of

herbicide applicators, and harvester dealers.

INCREASING OUR WETLAND RESOURCES, Proceedings of a Conference Sponsored by the National Wildlife Federation-Corporate Conservation Council, October 4-7, 1987, Washington, D.C. Edited by J. Zelazny and J.S. Feierabend. 1988. 363 pages. (Order from National Wildlife Federation, 1400 16th Street N.W., Washington, D.C. 20036-2266.)

This is a collection of 61 papers presented at this conference about wetlands creation and restoration.

A CITIZENS' GUIDE TO PROTECTING WETLANDS by J. Goldman-Carter, National Wildlife Federation, Washington, D.C. 1989. 64 pages. (Order from National Wildlife Federation, 1400 16th Street NW, Washington, D.C. 20036-2266. \$10.25)

This guide is for those "concerned citizens fighting to protect their wetlands." It summarizes wetlands legislation and provides names and addresses of agencies responsible for wetlands. It suggests the steps to take for citizens who want to monitor and challenge wetlands regulation decision-making.

WATER GARDENING BASICS by W.C. Uber. 1988. 173 pages. (Order from Dragonflyer Press, 2460 North Euclid Avenue, Upland, California 91786-1199.)

This is a slick, colorful book which gives step-by-step instruction for building ponds, fountains and waterfalls; balancing water chemistry; and selecting and caring for ornamental aquatic plants. There are also separate sections on the varieties of water lilies and fishes which you may choose, as well as animals which may be attracted to your pond.

REVIEW OF SENESCENCE AS AN IMPORTANT FACTOR DETERMINING THE RELATIONSHIP AMONG AQUATIC PLANTS, THEIR EPIPHYTES AND PATHOGENS, by E. Rejmankova. 1989. 107 pages. Miscellaneous Paper A-89-3, U.S. Army Corps of Engineers, Vicksburg, Mississippi. (Order from National Technical Information Service, 5285 Port Royal Road, Springfield, VA. 22161.)

This is a review of the role of microorganisms in senescence of aquatic plants. It presents the possible mechanisms which induce senescence (light, day length, temperature, nutrients and pathogens) and describes epiphytic microorganisms (algae, bacteria and fungi) associated with aquatic plants.

WATERPLANTS IN AUSTRALIA, by G.R. Sainty and S.W.L. Jacobs, Royal Botanic Gardens, Sydney. 1988. 144 pages.

(Order from Sainty and Associates, Vegetation Management, Box 1219 Potts Point, Sydney, N.S.W. 2011, AUSTRALIA. \$9.00.)

This is a unique pocket-sized identification book on the 70 most common indigenous and exotic aquatic plants of Australia (excluding algae). Color photographs and drawings of special features accompany descriptive notes about each plant. A very useful feature of this book is its extensive use of color-coded drawings which are keys to the growth habits, leaf shapes and leaf arrangements of the plants.

BIOLOGY OF SEAGRASSES - A Treatise on the Biology of Seagrasses With Special Reference to the Australian Region, edited by A.W.D. Larkum, A.J. McComb, and S.A. Shepherd. 1989. 885 pages.

(Order from Elsevier Science Publishing Co. Inc., P.O. Box 882, Madison Square Station, New York, N.Y. 10159. \$152.75.)

This work is "the first attempt to present a comprehensive treatment of seagrasses in all their varied aspects." It is an unequalled compilation of the present knowledge of seagrass systems and processes, and is written for specialists as well as students and those concerned with coastal resource management and conservation.

The text includes 24 chapters on taxonomy, structure, pollination, reproduction, evolution, biogeography, dynamics, decline, nutritional ecology, epiphytes, sediment interaction, ecology of fish, turtles and dugongs, productivity, gaseous movement, carbon metabolism, water relations, and metal accumulation. Also included are chapters on regional studies of seagrasses in Australia.

THE NUTRIENT ASSIMILATION CAPACITY OF THE LITTLE WEKIVA RIVER - Final Report, by D.E. Canfield and M.V. Hoyer, University of Florida, Department of Fisheries and Aquaculture, Center for Aquatic Plants. 1988. 288 pages.

This is the result of a three year research project to assess the effects of wastewater discharge on stream hydrology, water quality and biology, with primary emphasis on the relationship between stream nutrient concentrations and the abundance of aquatic plants and animals. The studies were conducted on the Little Wekiva and 16 other small streams in Florida.

The authors found that nutrient enrichment was not the primary factor controlling the abundances of aquatic plants in the Little Wekiva River and other small Florida streams. Aquatic plant abundances were controlled primarily by physical factors such as substrate quality, current velocity and shading. Of these, shading (by stream-bank forest canopies) was the dominant factor controlling the location and abundance of aquatic macrophytes. They also found that erosion caused by human activities "may be the most insidious problem requiring immediate attention."

NEW USES . . .

"A biobattery of a new type, in which pH difference between two media serves as a source of free energy, is described. The ability of some algae and other water plants to change markedly the pH of their surroundings according to the light conditions can be used to maintain two solutions at widely differing pH values. Electrical energy may be obtained from this source as a by-product to biomass production. The acid-base principle has not yet been exploited in construction of biobatteries."

From: Nespurkova, L.; Rybova, R.; Janacek, K. 1988. Acid-base solar biobattery exploiting water plants. *Acta Biotechnol.* 8(1):99-102.

CALL FOR RIVER PAPERS

Here is a new journal which deals with the protection and management of the nation's rivers. **RIVERS** will be released in late 1989.

RIVERS is a quarterly journal which "offers a multidisciplinary forum for research and professional literature addressing the issues of in-stream flow...and will focus on the science, environmental policy and law of in-stream flow". Original research and scholarly articles are solicited.

For a "Call for Papers" and more information, contact Susan E. Lamb, Editor, **RIVERS**, 3024 Phoenix Drive, Fort Collins, Colorado 80525.

REPORT YOUR RESEARCH!

The Federal Aquatic Plant Management Working Group (FAPMWG) is soliciting research summaries for inclusion in their next compilation. FAPMWG periodically publishes the compilation and also sends each contributor a free copy of the final document. To ensure that your work is included, submit your one-page summary using the following structure. They expect to complete the compilation by November 1989, so act quickly.

AGENCY:

PROJECT TITLE:

KEY WORDS:

STATUS: Starting Date: Completion Date:

CONTACTS:

PROJECT LEADER

PRINCIPAL INVESTIGATOR

PROJECT ABSTRACT:

PUBLICATIONS: (about this project)

Send this to Dr. A. Leon Bates, Aquatic Biology Department, Tennessee Valley Authority, OSA IS 122B, Muscle Shoals, Alabama 35660.

NATIONAL WETLANDS NEWSLETTER

Wetlands protection is one of the fastest growing areas of the law. Increasingly, wetlands and related land and water regulations affect a wide range of development and planning actions.

A publication of the Environmental Law Institute, the **National Wetlands Newsletter** provides coverage of legislative and regulatory developments. Federal, state, regional and local developments are closely monitored. In addition, this valuable source covers litigation: an "In The Courts" section presents case briefs on significant wetlands and coastal zone cases. Each issue also lists recent professional journal articles on wetlands, floodplains and coastal zone issues; reviews on technical, management and scientific books and reports; and upcoming conferences, symposia and workshops.

A one-year subscription to the newsletter includes six issues and costs \$48.00. Back issues are also available. For additional information, contact the National Wetlands Newsletter, Environmental Law Institute, 1616 P Street, NW, Suite 200, Washington, DC 20036, (202)328-5150.

Florida DNR and BioControl

A recent thrust of the Florida Department of Natural Resources is to become more involved in biological control research in the state. To this end, Ms. Jackie Jordan joined the DNR staff in Tallahassee as an aquatic biologist in March of this year. Jordan earned degrees in Resource Conservation and Resource Economics from the University of Florida. She worked in UF's Department of Entomology for 2-1/2 years, and spent 1-1/2 years with the Department of Environmental Regulation studying the results of revegetation and mitigation projects as an Environmental Specialist.

Ms. Jordan's duties include reviewing contractual biocontrol projects funded by the DNR, training regional biologists in the identification and habits of biocontrol insects, rearing insects for release as biocontrol agents, and monitoring studies in conjunction with other insect biocontrol release programs.

Jordan recently completed mass releases of the *Neohydronomus* weevil at ten statewide sites for the control of water lettuce (*Pistia stratiotes*). An immediate goal of Jordan's is to produce a viable population of the *Hydrellia* fly for statewide release at hydrilla infestations. She also is considering biocontrol options for the St. Mark's National Wildlife Refuge where a moratorium has been declared on herbicide spraying.

According to Jordan, another DNR goal is to establish a database of insect biocontrol populations in the state. As the first step, the 1989 DNR aquatic plant survey will include a survey of biocontrol evidence on water hyacinths statewide. Regional biologists will be collecting insects from plants, recording how many insects are present and how much damage exists among the plants. The 1990 survey will include biocontrol evidence on all aquatic plants.

Jordan is currently searching for farm ponds or irrigation canals containing water lettuce or hydrilla which have not been treated with herbicides or stocked with grass carp. Please notify her of any such water bodies which could be analyzed for potential use as insect stocking sites.

Ms. Jordan is available for information on biological control and can provide local contacts for further information. Call or write her at (904)487-2600, 3917 Commonwealth Blvd., Room 120 Annex, Tallahassee, FL 32303.

THE USE OF ELODEA AS A FEED FOR LABORATORY ANIMALS

by Riverside High School student Lisa C. Gorman, Rt. 2, Box 150, Chattaroy, Washington 99003. Ms. Gorman took top honors in the Washington State Junior Science and Humanities Symposium for her work.

In an attempt to find a good use for river plants, an experiment was devised in which Elodea was fed to laboratory rats.

I had a personal interest in this plant as it grows in the Little Spokane River that flows through my family's property. I hated how this plant grew in our swimming area and I tried to pull it up. No matter how much I pulled up, it grew back quickly. I thought it was interesting that my dog and market sheep would eat whatever plants that I threw up onto the river bank. I decided to see if this plant had any value as an animal feed. Commercial livestock feeds are becoming so expensive that it is almost impossible to break even with production costs. I hoped that by combining this readily available plant with other feeds it could reduce the cost of feeding my animals. I know that aquatic plants are eaten in some cultures and that algae is found in health food stores as a nutritional supplement.

The purpose was to see if the rats fed a percentage of Elodea would grow faster, slower or at the same rate as those fed regular rat food. It was hoped that the rats would accept the flavor of the plant and that a method could be found to make feeding them the plants practical. Research was also done on other fresh water plants that have been studied for their nutritive value. The alga Chlorella is one which is produced commercially in Japan and other countries as a nutritive supplement.

Eight week old rats, weighing between 60-80 grams were obtained, divided by sex and split into three groups. When the first group reached maturity, 200-250 grams, and their growth rate slowed, a second run was made to confirm results.

Elodea was harvested and fed free choice to all of the test rats. They ate it readily and were not put off by the strong smell or flavor. Feeding it fresh was impractical because it was too wet and it was impossible to measure consumption. Therefore, the Elodea was dried outside on screens and this was fed to the rats. They didn't seem to like the flavor and the plants fell apart too easily. After a number of trials it was found that dried, powdered Elodea could be mixed successfully with Purina Lab Chow to make an acceptable feed. Feed biscuits were made with 10% Elodea and 90% Lab Chow, as well as with 25% Elodea and 75% Lab Chow. The control group was fed 100% Purina Lab Chow. Each group was fed their respective feeds free-choice, with no other feed available.

Rats were weighed weekly and their weights were recorded to the nearest one-one hundredth of a gram. Weekly weight gains and losses were computed and these results were graphed. Results taking into consideration both the first and second trial runs showed that during the first six weeks the control group had consistent gains and no losses. The 10% group had the best weight gains at first but then experienced a weight loss. The 25% group gained consistently at first, but at a slower rate than either of the other two groups. They also had a weight loss during the fifth week. During the seventh through twelfth weeks the control group continued to gain at a rapid pace. The 10% group showed lower gains and the 25% group again showed gains at a rate slower than the other two. Final analysis showed the rats of the control group, fed 100% Purina Lab Chow, had the most consistent weight gains. They never had a weight loss and attained the greatest overall weights. In comparison, the 10% group grew the quickest for the first four weeks, but then slowed, never to catch up with the control group. The 25% group had the slowest overall rate of growth. These results seem to show that there was no conclusive result from this experiment but research gave possible reasons for the slow growth rates of the single stomached test rats.

A commercial company performed an analysis of Elodea which showed it to have a moderate protein content of 12.2%, a favorable oil content of 1.6%, an acid detergent fiber content of 41.3% and an ash content of 50.7%. The acid detergent fiber is what would have inhibited my test rats, as it is indigestible by single stomached animals but not by multi-stomached animals such as most livestock.

Although this experiment was conducted with Elodea, research showed a fresh water algae, Chlorella, to be a successful nutritional supplement. It has been studied for the past 25 years as a food and nutrient source for both humans and animals and has caused much excitement in the field of food technology. I was very privileged to meet with the president of Sun Chlorella Co., LTD, Mr. Hideo Nakayama from Japan, to discuss the nutritive value of his commercially produced Chlorella and its use as a supplement for humans and animals. We discussed the current research being done by his company.

COENOS

An IBM PC program for the Braun-Blanquet table technique of vegetation classification - Developed by Adolf Ceska and Hans Roemer. Cost: US \$85.00. For information, contact Dr. Adolf Ceska, P.O. Box 1761, Victoria, B.C., V8W 2Y1, CANADA.

The Braun-Blanquet table technique is an old, but very powerful method for analyzing vegetation data. A well sorted vegetation table is a large spread sheet in which similar vegetation samples are grouped together and their characteristic species form distinctive blocks. Such a table provides a clear insight into the structure of vegetation data; it displays both vegetation types and the specie that typify them.

The use of the table technique in its original form, however, requires an extensive apprenticeship, is time-consuming, relatively subjective, and feasible only for smaller data sets. For the description of the technique see Chapter 9 in Mueller-Dombois, D. & H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology*. John Wiley & Sons, New York.

COENOS enables the user to sort vegetation tables in minutes. A simple iterative algorithm establishes an objective basis for the technique, and COENOS can analyze reasonably large data sets. It is based on our earlier main frame program (Ceska, A. & H. Roemer, 1971. A computer program for identifying species-releve groups in vegetation studies. *Vegetatio* 23: 255-277). When the program was adapted for microcomputers, numerous features were added to make COENOS extremely user-friendly. The program flow is well documented on the screen and the user can access context-sensitive help screens whenever he needs more information.

The COENOS program has the following steps:

1. Reading the data.
2. Extraction of species/releve groups.
3. Ordination of species/releve groups.
4. Display of the final vegetation table.
5. Printing of the table.

The full vegetation table provides an excellent insight into the structure of vegetation data. COENOS can be used either before more complex multivariate techniques are applied or after, when the vegetation table can be rearranged to reflect the results of the sophisticated techniques in order to understand their performance.

COENOS is available for the IBM PC and compatible microcomputers (PC-DOS or MS-DOS 2.0 or higher) and the IBM PS/2 series. It supports all IBM compatible printers and can handle up to 520 releves and 450 species.

THE NUTRIA PROBLEM - PART III: Reply to Rebuttal

by William H. Conner, Coastal Ecology Laboratory, Center for Wetland Resources, Louisiana State University, Baton Rouge, LA 70803 (504) 388-6358.

When AQUANOTES (Louisiana State University Sea Grant College Program) ran its article on nutria in December 1987, the issue of whether or not to term the release of nutria a "biocontrol mistake" was not one that concerned us very much; the results of nutria herbivory was our major concern. I agree with Davis and Buckingham (1988) that nutria were first introduced into Louisiana mainly for their fur potential. However, rumors also spread that nutria would eat almost anything including undesirable aquatic plants (Swank and Petrides, 1954; Harris, 1956; Lowery, 1974), and this helped spread the release of nutria throughout coastal Louisiana. Unfortunately, nutria never lived up to their reputation as eaters of undesirable aquatic plants.

What they did live up to was their ability to become a major fur animal in the state. Nutria were imported into Louisiana and released several times in the late 1930s-early 1940s without developing a breeding population of animals (O'Neil, 1949; Kays, 1956). However, the animals imported by E.A. McIlhenny for experiments in pen raising nutria multiplied rapidly and many escaped (Lowery, 1974). In 1940, a hurricane passed through the area and another 150 animals escaped. These animals, plus others released by landowners in the early 1940-50s, multiplied rapidly and established themselves in the marshes and swamps of Louisiana. By 1959, there were over 20 million nutria in Louisiana (Lowery, 1974). The first pelts reached the fur market in 1943-44. The harvest has grown to where nearly 1 million pelts were harvested in the 1986-87 trapping season.

The impact of these animals on vegetation in the swamps and marshes of Louisiana was the main subject of the AQUANOTES article. Studies at Louisiana State University have shown that nutria are severely restricting planting efforts in many of the cypress swamps in the state, and they are also limiting marsh growth and spread in freshwater and brackish marsh areas. Nutria ate baldcypress seedlings almost as fast as they were planted in logged over areas (Conner and Toliver, 1987; Conner, 1988). In the Atchafalaya delta area, freshwater marsh successional patterns are affected by heavy grazing of nutria. Only when nutria are excluded from the marsh by fences do dense stands of vegetation develop (Fuller et al., 1985; Rejmanek et al. 1987). The same pattern has been observed in the brackish marshes near New Orleans. Planted *Spartina alterniflora* seedlings were eaten within days of planting unless fences were built around the seedlings (Day et al., in press).

In Louisiana wetlands, both swamp forests and marshes, nutria seem to be a dominant force in destroying desirable vegetation and preventing revegetation. It is very important that we understand the full impact of this introduced species on wetland ecology and develop plans to control their

destruction. At LSU, proposed studies will attempt to measure the impact of real and simulated nutria grazing on the productivity, recovery, and spread of *Spartina* marshes and develop a model to predict marsh growth as a function of nutria population.

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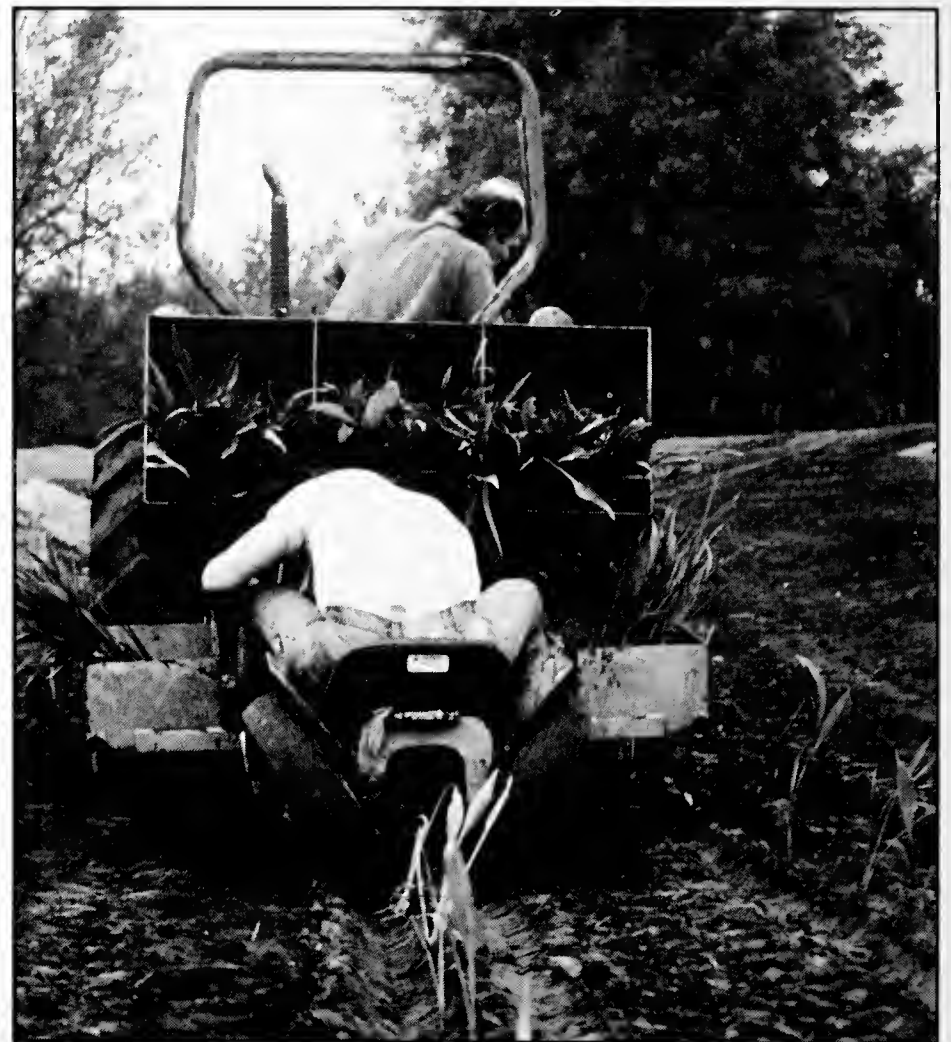
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TRANSPLANTING MADE EASY

Transplanting large areas of aquatic plants is made easier by the use of this specially adapted planting tractor. Here, Michael Reilly of The Wetlands Company (Sarasota) plants *Sagittaria* in a newly constructed retention pond in a Hillsborough County housing development.

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MEETINGS

13TH ANNUAL MEETING - FLORIDA AQUATIC PLANT MANAGEMENT SOCIETY. October 17-19, 1989, Holiday Inn, Daytona Beach, Florida.

This is THE meeting for managers and field personnel in Florida. Join the 400 others who will attend this 3-day educational meeting which also counts towards re-certification. To present a paper, contact Ken Langeland, Center for Aquatic Plants, 7922 N.W. 71st Street, Gainesville, FL 32606 (904) 392-9613. To pre-register, send \$30 to Vic Ramey, Treasurer, FAPMS, Rt. 1 Box 217-A, Micanopy, FL 32667. (Registration at the door will be \$35.00.)

9TH ANNUAL INTERNATIONAL SYMPOSIUM - NORTH AMERICAN LAKE MANAGEMENT SOCIETY. November 7-11, 1989, Stauffer Hotel, Austin, Texas.

Nearly 100 papers on lake and reservoir management will be presented in concurrent sessions during three days. This year's theme is "Multiple-Use Management of Reservoirs." The meeting will also include non-technical "Citizens Sessions" on lake problems and solutions.

For more information, contact NALMS, P.O. Box 217, Merrifield, Virginia 22116 (202) 466-8550.

8th INTERNATIONAL SYMPOSIUM ON AQUATIC WEEDS, EUROPEAN WEED RESEARCH SOCIETY. August 13-17, 1990, Swedish Agricultural University, Uppsala, SWEDEN.

The Symposium theme: Environmental issues in relation to aquatic weed control. The program will cover six subject areas: biology and ecology of aquatic weeds; aquatic plant management in temperate and tropical regions; environmental manipulation in aquatic plant management; exploitation of aquatic plant management; problems in the management of non-vascular aquatic plants; and herbicide pollution of freshwater ecosystems.

For more information, contact Kevin Murphy, Department of Botany, University of Glasgow, Glasgow G12 8QQ, UNITED KINGDOM.

WETLAND IDENTIFICATION AND DELINEATION, A Course for Professionals. August 14-18, 1989, University of Massachusetts, Amherst.

Instructors Ralph Tiner and Peter Veneman will "provide you with the appropriate background to perform wetland identifications using any of the accepted systems", by training in wetland plant identification, hydric soil recognition and wetland hydrology identification. The week-long course involves classroom and field instruction, emphasizing the latter. The registration fee is \$675.

For more information, contact Alice Szlosek or Trudie Goodchild, Division of Continuing Education, 608 Goodell Building, University of Massachusetts, Amherst, MA 01003. (413) 545-2484.

WATER: LAWS AND MANAGEMENT. September 17-22, 1989, Tampa, Florida.

This is the 25th annual conference of the American Water Resources Association. The conference will review wetland management policies and wetland values.

For information, contact Ken Reid, American Water Resources Association, 5410 Grosvenor Lane, Ste. 220, Bethesda, Maryland 20814-2192, (301) 439-8600.

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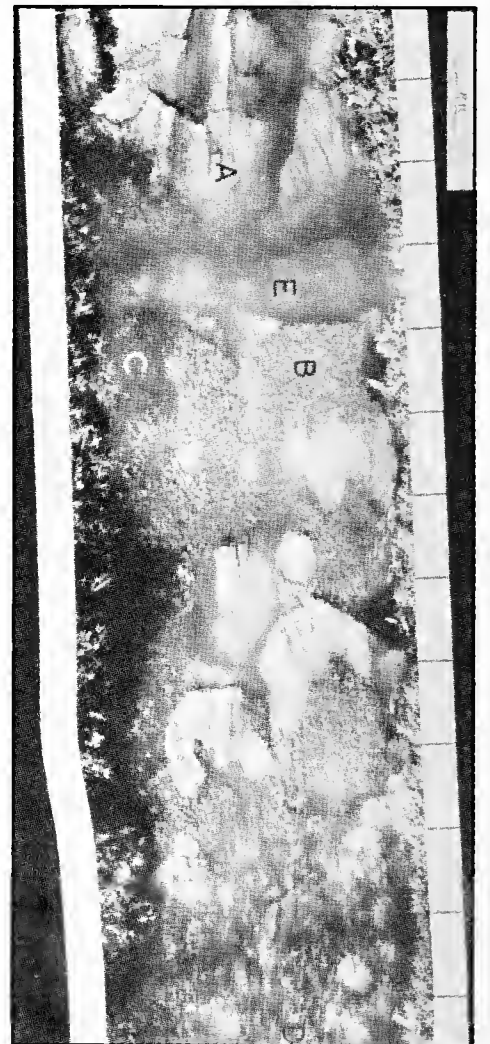
This is the newsletter of the Center for Aquatic Plants and the Aquatic Plant Information Retrieval System (APIRS) of the University of Florida Institute of Food and Agricultural Sciences (IFAS). Support for the information system is provided by the Florida Department of Natural Resources, the U.S. Army Corps of Engineers Waterways Experiment Station Aquatic Plant Control Research Program (APCRP), the South Florida Water Management District, the Lake County Water Authority, and the St. Johns River Water Management District.

EDITOR: Victor Ramey

ASSISTANT: Karen Brown

AQUAPHYTE is sent to 3,500 U.S. and Canadian managers, researchers and agencies. Comments, announcements, news items and other information relevant to aquatic plant research are solicited.

We gladly permit free republication of *AQUAPHYTE* items when accompanied by full acknowledgement.



Aerial photographic apparatus used to survey macrophytes, 1958.

"Recording of the distribution of aquatic macrophytes in shallow rivers, lakes and ponds is both tedious and difficult from banks or from a boat. The expense of aerial surveys is rarely justified, and when photography from the banks is employed, interpretation of results and surface reflections at low angles of incidence are troublesome. Good results have now been obtained by suspending an electrically operated camera from a balloon filled with hydrogen and secured at a constant height above ground level. This method was developed primarily to study the relative weed cover and weights of plants in a chalk stream."

From: Edwards, R.W.; Brown, M.W. 1960. An aerial photographic method for studying the distribution of aquatic macrophytes in shallow waters. *J. Ecology* 48:161-163.